Ignition coil primary bobbin issue analysis

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Abstract: Ignition coil is an important component in the engine ignition system, the ignition coil issue may cause engine idling shaking. I present some types of ignition coils used in this article nowadays, and analyze the engine idling shaking, coil secondary voltage lower quality issue caused by the different primary bobbin raw material hot deformation when the temperature decreasing, make the action plans and lesson learns. It can be used for the ignition coils design validation and quality management later.

Introduction

Ignition coil is an important component in the engine ignition system, its function is convert vehicle 12V DC voltage into 35KV AC voltage according to the step-up transformer in the coil, and input the voltage to the spark plug, let it ignite the mixed air-gasoline. The opening and closing of the primary circuit controlled by the engine ECU.

The working process can be divided into 4 steps, the diagram is as Fig 1.

Step1: primary circuit load: The power switch is closed, the current flows through the primary coil until it reaches atypical value (6 to 10 A).

Step2: spark creation: The power switch is opened. The magnetic flux in the magnetic circuit suddenly fell to zero. This fast change creates a high voltage at the secondary coil and then at the electrodes of the spark plug, then the spark is initiated.

Step3: discharge of coil energy into the spark: The energy previously stored in the magnetic circuit is discharged in the spark.

Step4: End of the spark: The sparkstop when all energy was gone.

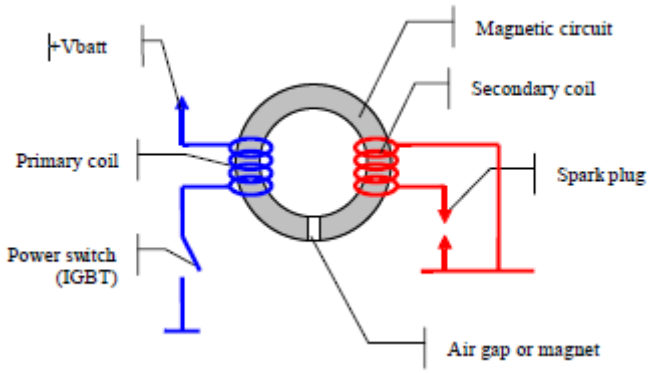

Fig 1: Ignition system diagram

Nowadays, 4 types ignition coils normally used in the vehicles according to the shapes, they are Compact type, rail type, pencil type and top plug type(see Fig 2). The famous supplier for the ignition coils are DELPHI, BOSCH, VALEO, ELDOR and BORGWARNER, etc.

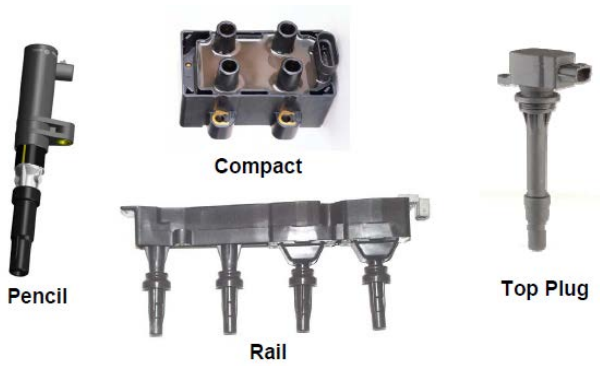

Fig2: Ignition coil types

Problem Description

Let's start from the rail ignition coil internal structure, it included coil module, capacitor, command wires, resin, connector, lead-frame, housing, EMC filtering element, rubber boot, spring etc.(see Fig 3). The coil module made by primary bobbin, secondary bobbin, module housing, magnetic C-core and magnetic T-core etc. (see Fig 4).

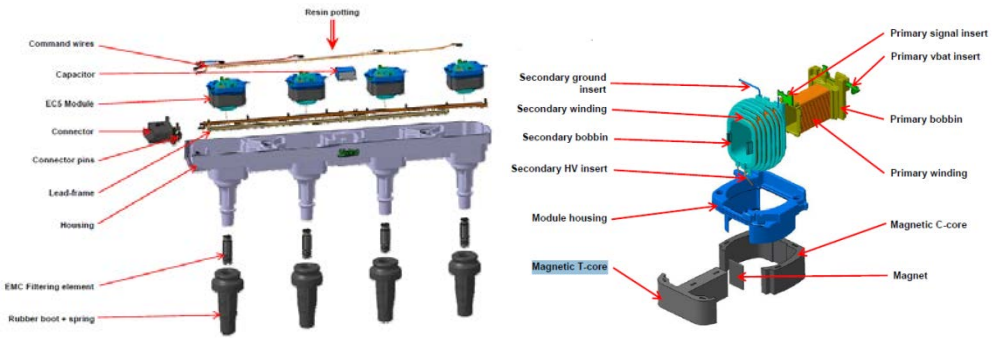

Fig3: rail ignition coil exploded chartFig4: coil module exploded chart

In the January of 2016, there were 3pcs 0km quality issues happened in the assembly line, when did the final test we found the engine idling shaking caused by the NOK ignition coil. The defect parts had been analyzed by the supplier VALEO, and they confirmed that all of the ignition coils secondary voltage were lower than specification, caused by the resin cracked and insulation function not OK anymore. And all of the defect ignition coils were produced in the December of 2015, and the primary bobbin are produce by the new tier2 supplier Autowin. But in the past years when we used the old tier2 supplier Microspire produced primary bobbin, we hadn't any issues.

Root Cause Analysis

When we disassemble the NOK parts(using Autowin primary bobbin) and OK parts(using Microspire primary bobbin) we found that there are resin sticking in the T core only for the Autowin primary bobbin, so we had the conclusion that Using the Autowinprimary bobbin change the resin behavior.(see Fig5)

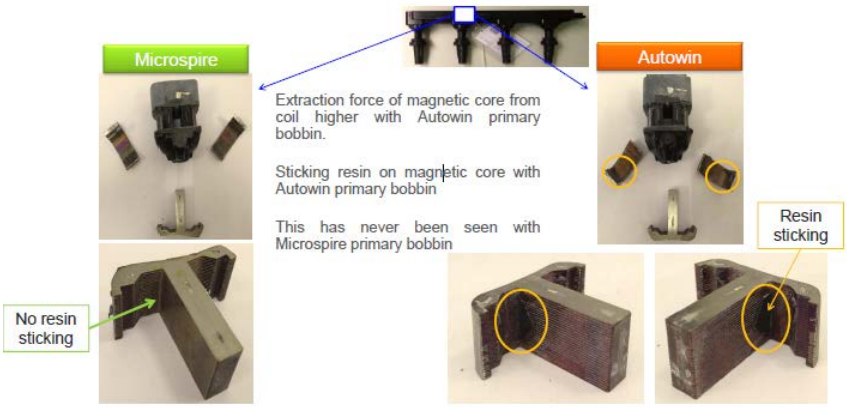

Fig5: the comparison of primary bobbin

According to the DOE test we confirmed that the raw material DupontCrastin LW9320 used by Autowin is the root cause of the sticking, it was different with raw material DSM Arnite TV4 used by Micorspire. The coil assembly site, primary bobbin supplier process, primary bobbin injection process are not factors of the sticking.

(1)Why use of DupontCrastin LW9320 increase resin sticking on T core?

DupontCrastin LW9320 used by Autowin is a PBT-GF20 with SAN additive (Styrene AcryloNitrile), SAN additive is used to lower the warp age during injection process, and increase adherence with epoxy resin. But Microspire raw material DSM Arnite TV4 is a PBT-GF20 without SAN additive, so SAN additive explain why we can see sticking effect of resin on T core in Autowin primary bobbin version.

(2)Why sticking of resin on T core induce cracks in resin?

The Thermal dilatation coeffcient of T core is very different with resin and plastic, when the outside temperature decreased from high to low quickly, T core retract far less than epoxyresin and plastic material, if there are plastic Sticking in the T core, the primary bobbin can't slide on T core, and the Sticking of resin on T core induces a traction stress in epoxy resin, if the force over the stress target, the resin maybe cracked, caused the insulating strength lower than specification, and the voltage not high enough to ignite. The detailed analysis we can see Fig6.

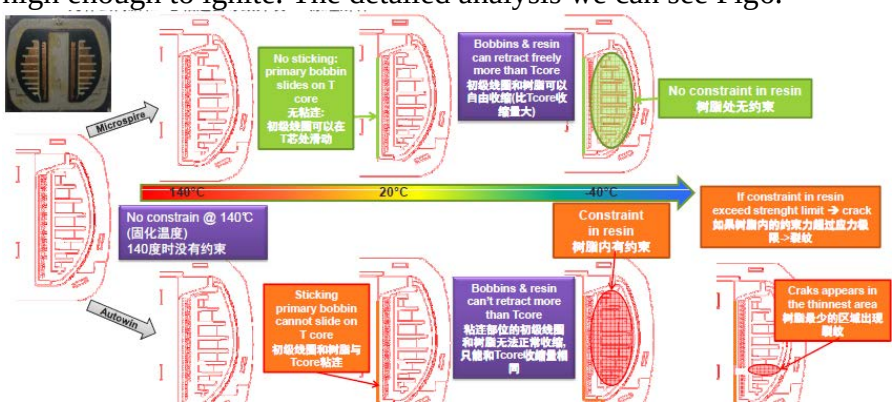

Fig6: resin cracked analysis

(3).Why only few of Autowin parts failed?

All current Autowin parts use DupontCrastin LW9320 raw material which increase sticking of resin on T core, and thus mechanical stress in resin when temperature change, because the distribution of stress in resin, on a majority of parts, the increase of mechanical stress is not sufficient to go over the strength limit of the resin, those parts will never failed. But On a small quantity of parts, the mechanical stress goes over the strength limit of the resin, create cracks and di-electrical failure. That is to say, due to statistical distribution of stress and strength in epoxy resin, only few part failed, others will never failed.

Corrective Action

According to the analysis reason as above, we changed the primary bobbin tier2 supplier to Microspire, after that no any new defect parts until now.

Lesson Learnt

(1) If any change of the injection molding location, injection molding supplier (including double sourcing), raw material manufacturing location and raw material reference, we need do the Qualification tests with cut of parts and comparison of parts before and after modification.

(2) We should optimize the current inspection method, add 5 cycles of thermal shock 2h/2h +140/-40°C, before current 100h RPA test.

Conclusions

In this article I presented a typical quality issue about the raw material change. I think it is a good sample for the design or quality engineer of ignition coil, we should pay more attention for the same model material using different prescription, if any change about that, we need get more information from the raw material suppliers. It also can be reference for the new plastic supplier chosen.

Acknowledgements

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